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(54) Title: Separator for producing oxygen

[(57) Abstract: A separator is described that is especially suitable for the generation of oxygen.

The separator in accordance with the invention permits the achievement of adequate cooling of all highly pressure-loaded metal parts. In addition, a safe, gas-tight passage from the area of a pipe designed as a membrane pipe to the metal components of the pipe is guaranteed. In addition, damaged pipes can be replaced simply and rapidly.

Furthermore, the separator in accordance with the invention is designed as conventionally as possible, so that the traction of ceramic components can be kept small.

Specification

[0001] The invention pertains to a separator that is especially suitable for the production of oxygen.

[0002] For producing oxygen a gas-tight, oxygen ion- and electron-conducting ceramic membrane is supplied on one side (retentate side) with an oxygen-containing gas mixture. On the other side of the membrane (permeate side), pure oxygen can then be removed.

[0003] The oxygen ion transport through such ceramic membranes however takes place in the desired direction only when the oxygen partial pressure on the retentate side is larger than on the permeate side. In the production of pure oxygen this can be achieved in that the oxygen-containing gas mixture supplied to the ceramic membrane is compressed and/or a pressure reduction is achieved on the permeate side, thus on the side of the pure oxygen stream that is to be obtained.

[0004] The optimal operating or effect range of available ceramic membranes lies at temperatures between 700°C and 1,100°C.

[0005] A large number of separator designs are known—reference may be made to EP-A 0,875,281—that serve for production of oxygen with the aid of a ceramic membrane. However, a drawback in the case of the known separator designs is that on one hand they are expensive to build, and on the other hand the required cooling of the pressure-loaded metal components required because of the high temperatures cannot always be guaranteed. In addition, replacement of damaged parts in the case of the known design is possible only with a relatively high expense.

[0006] The goal of the present invention is to supply a separator for production of oxygen that avoids the disadvantages mentioned.

[0007] To solve this problem, a separator is suggested with

-a separator jacket
-two covers closing the two ends of the separator jacket
-wherein each cover has at least one opening

-at least one pipe plate arranged in the upper region of the separator
-an interior container arranged beneath the pipe plate
-a partition arranged essentially at a right angle in the container and having openings for pipes, which subdivides the inner container into an upper and a lower gas space
-at least two openings corresponding to the upper gas space and arranged in the separator jacket
-at least two openings corresponding to the lower gas space
-wherein one of the openings is arranged in the separator jacket and the other opening(s) is arranged in the face and/or the side walls of the inner container
-several pipes suspended in the pipe base
-wherein the pipes extend through the partition into the lower gas space
-at least partially made as membrane pipes
-and the area of the pipes constructed as membrane pipes is preferably arranged in the lower gas space.

[0008] Additional advantageous embodiments of the separator in accordance with the invention are objects of the subclaims.

[0009] The separator in accordance with the invention and further embodiments thereof will be explained in greater detail on the basis of the exemplified embodiment shown in the figure.

[0010] The figure shows a lateral sectional view through a possible embodiment of the separator in accordance with the invention.

[0011] Separators of this type are generally provided with a cylindrically symmetrical design. They can be arranged either upright—as is shown in the figure—or in any other alignment, for example a horizontal one. In the following, the upright arrangement shown in the figure will be described.

[0012] The separator consists of a jacket 1 and two covers 2 and 5 that close off the two ends of the jacket 1. Each cover 2 and 5 has at least one opening 3 and 6. In practice the lower cover 5—contrary to the representation in the figure—is designed only as a base.

[0013] According to an advantageous embodiment of the separator in accordance with the invention, on the inside of the separator jacket 1 and/or on the inside of one or both covers 2 and 5 a thermal insulating layer may be applied.

[0014] A heat protecting insulation of this type serves to keep the temperature of the separator jacket, which may be exposed to heavy pressure stress, at a relatively low level.

[0015] In the upper region of the interior of the separator, a pipe base 8 is arranged. Beneath this pipe base 8 in turn the inner container 10 is arranged. This is subdivided by a partition 11 arranged essentially at a right angle to the side walls of the container 10 into an upper gas space 12 and a lower gas space 13.

[0016] In the pipe base 8 a number of pipes 20 are inserted or insertable—however for the sake of simplicity only one pipe 20 is shown in the figure. For this purpose the pipe base 8 preferably has pipe pieces 9 that are welded into it and into which the pipes 20 are inserted. The pipes 20 inserted in this way are tightly welded with the pipe pieces 9. If defective pipes 20 must be replaced, these can be removed from the pipe base 8 after the weld seam has been eliminated. However, the welding described is not urgently necessary, since under certain circumstances it is possible to completely avoid a permanent bonding, or bonding methods alternative to welding may be used.

[0017] The pipes 20 inserted into the pipe base 8 extend over the upper gas space 12 through openings 24 provided in the partition 11 at least into the lower gas space 13.

[0018] Corresponding to an advantageous design of the separator in accordance with the invention, the pipes 20 preferably extend through the base of the inner container 10 into the gas space 7 located beneath the inner container 10. For this purpose corresponding openings 23′ are provided in the base of the inner container 10. By means of this advantageous embodiment and additional guidance of the pipes 20 in this region is achieved.

[0019] In addition the pipes 20 have metal bellows 19 attached preferably in the area of the openings 24 provided in the partition 11 for the purpose of sealing, wherein these are fastened with one of their ends on the pipes 20, preferably gas tight. The fastening in this case once again preferably takes place by welding, but here also alternative connection methods are conceivable.

The pipes 20 are thus fixed in a sliding manner in the area of the partition 11. The provision of a metal bellows 19 permits adequate assurance against large leaks between the gas space 12 and the gas space 13, since the metal bellows 19 lie with their open ends on the partition 11. It is also conceivable that the open ends of the metal bellows 19 are connected with the partition 11 by means of a suitable mechanism.

[0020] The pipes 20 are at least partially designed as membrane pipes 21. In this process the area of the pipe 20 designed as a membrane pipe 21 is arranged in the lower gas space. It is also conceivable that the area of the pipe 20 designed as a membrane pipe 21 extends into the upper gas space 12.

[0021] The area of the pipe designed as a membrane pipe 21 can be designed either in the form of a gas-tight, oxygen ion- and electron-conducting ceramic membrane applied to a gas-permeable support pipe or in the form of a pipe made of a monolithic, gas-tight, oxygen ion- and electron-conductive ceramic.

[0022] In the separator design shown in the figure, the area of the pipe 20 designed as a membrane pipe 21 is connected in a material-locking fashion at both ends with one metal pipe each of approximately the same diameter and is connected coaxially. The pipes 20 are fixed in the pipe plate 8 at only one of their ends, whereas the respective opposite end, closed gas-tight, is held or arranged freely expandable in the axial direction and slidingly to avoid stresses due to different thermal expansions.

[0023] Both the upper gas space 12 and the lower gas space 13 have at least two openings assigned to them. In the case of the upper gas space 12 these are the openings 15 and 16, wherein the opening 16 also has assigned to it a guide panel 17, and in the case of the lower gas space 13, the openings 23 and 18.

[0024] The hot, oxygen-containing gas mixture is conveyed to the separator in accordance with the invention over the opening 6 provided in the lower plate 5 into the gas space 7 found below the inner container 10. The oxygen-containing gas mixture has a temperature of 850°C at a pressure of 15 bar. The production of such a gas mixture can for example take place in a combustion chamber under exclusion of fresh air. Through the openings 23 arranged in the lower plate of the inner container 10, this gas mixture passes into the lower gas space 13. It now flows

around the region of the pipe 20 formed as a membrane pipe 21. In this process pure oxygen passes into the interior 22 of the pipe 20, in which the oxygen partial pressure with a value of, for example, 0.2 bar is substantially lower than in the lower gas space 13. The oxygen that has entered the interior 22 of the pipe 20 is removed from the pipes 20 and cooled to a temperature of about 250°C.

[0025] This cooling is accomplished in that through the opening 15 fresh air that has a temperature of 130°C at a pressure of 15.5 bar is conveyed into the upper gas space 12. The air heated against the hot oxygen to be cooled in the interior 22 of the pipe 20 to a temperature of about 250°C is then withdrawn through the channel 14 and the opening 16 formed by the air guide panel 17 from the separator and, if desired, introduced into the previously mentioned combustion chamber to produce the oxygen-containing gas mixture.

[0026] Through the gas space 4 and the opening 3 arranged in the upper cover 2 the pure oxygen stream cooled in this way is withdrawn at a pressure of 0.2 bar and a temperature of 250°C. From the lower gas space 13 over the opening 18 a hot gas mixture, depleted in oxygen, is withdrawn and if desired sent for further energy utilization.

[0027] The pipe base 8, which is exposed to a pressure difference of 15.3 bar, is heated to a maximum temperature of 250°C in the separator design in accordance with the invention.

[0028] In addition, in the separator design in accordance with the invention, the higher pressure prevails on the outside of the pipe 20. This is advantageous since in general the pressure resistance of ceramic is higher than its tensile strength.

[0029] Not shown in the figure are so called turbulence enhancers that serve to improve material transfer and that are preferably designed in the form of turbulizing (guide) panels. These turbulence enhancers may be arranged in the lower gas space 13 between the pipes 20, preferably over the entire length of the membrane pipes 21, and/or in the upper gas space 12. In addition, to improve the internal heat transfer in the pipes 20, preferably in the region of the upper gas space 12, (additional) turbulence enhancers may be provided.

[0030] The separator in accordance with the invention makes it possible to achieve adequate cooling of all highly pressure-loaded metal components. In addition, a safe and gas-tight

transition from the area of one pipe, designed as a membrane pipe, to the metal component of the pipe is guaranteed. Furthermore, damaged pipes can be replaced relatively simply and rapidly. In addition, the separator in accordance with the invention is designed as conventionally as possible so that the number of ceramic components can be kept small.

[0031] In addition to the above mentioned membrane types, the separator in accordance with the invention is also suitable for the use of other membranes that can be integrated into the separator design in the manner described.

Claims

1. Separator with
   a separator jacket (1)
   two covers (2, 5) closing off the two ends of the separator jacket (1)
   wherein each cover (2,5) has at least one opening (3, 6)
   at least one pipe plate (8) arranged in the upper area of the separator
   an inner container (10) arranged beneath the pipe plate (8)
   a partition (11) arranged essentially at right inside the inner container (10), having openings (24) for pipes (20), and subdividing the inner container (10) into an upper (12) and a lower (13) gas space
   at least two openings (15, 16) corresponding to the upper gas space (12) arranged in the separator jacket (1)
   at least two openings (23, 18) corresponding to the lower gas space (13)
   wherein one of the openings (18) is located in the separator jacket and the other opening(s) (23) is located in the base and/or the side walls of the inner container (10)
   several pipes (20) suspended in the pipe plate (8)
   wherein the pipes (20 extend through the partition (11) into the lower gas space (13)
   at least partially designed as membrane pipes (21)
   and the area of the pipe (20) designed as a membrane pipe (21) is preferably arranged in the lower gas space (13).
2. Separator in accordance with Claim 1, characterized in that the area of the pipe (20) formed as a membrane pipe (21) is designed in the form of a gas-tight, oxygen ion- and electron-conducting ceramic membrane applied onto a gas-permeable support pipe.

3. Separator in accordance with Claim 1 or 2, characterized in that the area of the pipe (20) designed as a membrane pipe (21) is produced in the form of a pipe consisting of a monolithic, gas-tight, oxygen ion- and electron-conducting ceramic.
4. Separator in accordance with one of the preceding claims, characterized in that the pipes (20) extend through the base of the lower inner container (10) into the gas space (7) located beneath the base of the inner container (10).
5. Separator in accordance with one of the preceding claims, characterized in that on the inside of the separator jacket (1) and/or on the inside of one cover or the covers (2,5) a thermal insulating layer is arranged.
6. Separator in accordance with one of the preceding claims, characterized in that on the pipe plate (8), pipe pieces (9) are arranged, to which the pipes (20) can be fastened.
7. Separator in accordance with one of the preceding claims, characterized in that in the area of the openings (24) provided in the partition (11), the pipes (20) have gas-tight attached metal bellows (19), wherein these are fastened with one of their ends to the pipes (20), preferably gas-tight.
8. Separator in accordance with one of the preceding claims, characterized in that in the upper gas space (12) and/or in the lower gas space (23), turbulence enhancers are arranged.
9. Separator in accordance with one of the preceding claims, characterized in that turbulence enhancers are arranged in the pipes (20), preferably in the area of the upper gas space (12).
10. Separator in accordance with one of the preceding claims, characterized in that the separator is formed in a cylindrically symmetrical manner.

One page of drawings attached.

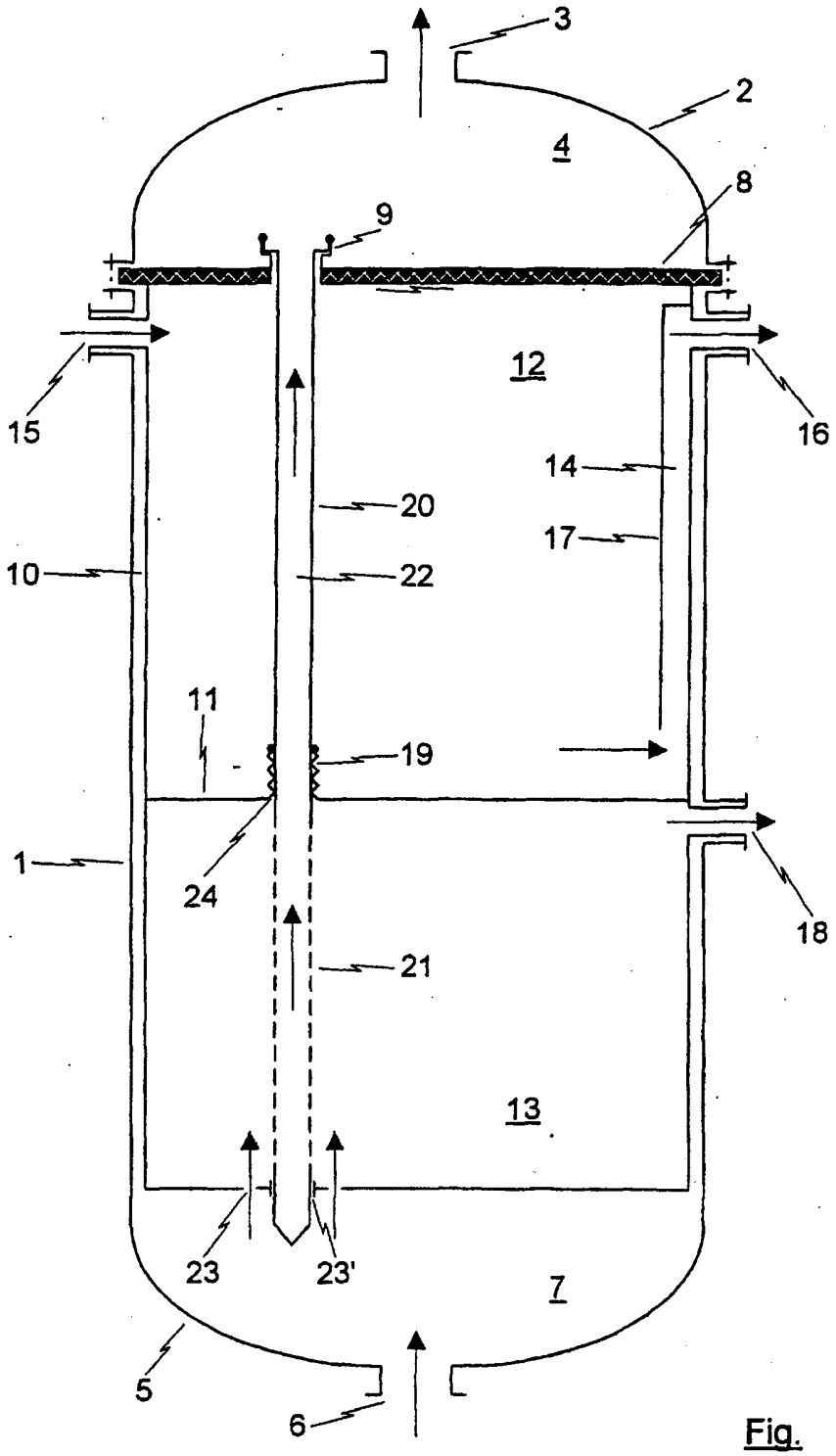

Fig.